

ENGLISH  
TRANSLATION  
OF INTERNATIONAL  
APPLICATION AS FILED

## DESCRIPTION

GAMMA CORRECTION CIRCUIT, DISPLAY PANEL, AND DISPLAY DEVICE HAVING  
THEM

## TECHNICAL FIELD

**[0001]** The present invention relates to a gamma correction circuit and a display panel and further relates to a display device such as a liquid crystal display device that has a gamma correction circuit and a display panel.

## BACKGROUND ART

**[0002]** Generally, a display panel of a display device such as a liquid crystal display device has a nonlinear correlation between an applied voltage and a brightness of a display element, that is, a gamma characteristic. Fig. 5 shows a typical gamma characteristic. Solid curve A in Fig. 5 is a characteristic (that is, a gamma characteristic) of a liquid crystal display element in which a voltage is applied as is without correcting (gamma-correcting) the image voltage ( $V_1$  or  $V_m$ , for example). In Fig. 5, the horizontal axis represents the applied voltage and the vertical axis is the relative brightness (that is, the optical transmittance of the liquid crystals). Now, if the image voltage ( $V_1$  or  $V_m$ , for example) is not gamma-corrected and is applied, a favorable image cannot be displayed due to conformity with the nonlinear correlation. Hence, in order to display a favorable

image, a corrected image voltage ( $VI_1$  or  $VI_m$ , for example) which is obtained by gamma-correcting the image voltage ( $V_1$  or  $V_m$ , for example) in order to follow the broken straight line B which represents a linear correlation between the image voltage and the brightness is taken as the applied voltage.

**[0003]** A gamma correction circuit that performs gamma correction in a liquid crystal display device in this way, as disclosed in Patent Documents 1, 2, or 3, for example, is known. Further, the present applicant proposed, in Patent Document 4, a gamma correction circuit for which the gamma correction circuits disclosed in Patent Documents 1, 2, and 3 represent the prior arts. Fig. 6 shows a liquid crystal display device that has the same gamma correction circuit as that of Patent Document 4. The liquid crystal display device 101 has a gamma correction circuit 105a that outputs gamma-corrected set voltages  $VI_1$  and  $VI_m$ , a source driver 6 to which image data  $Di$  of  $n$  bits (eight bits, for example) are input and which, by selecting a corresponding gamma-corrected set voltage of  $VI_1$  to  $VI_m$  or a corresponding interpolation voltage thereof (subsequently described), outputs a corrected image voltage  $V_o$  as an applied voltage to each of the source lines in a display panel 107 (subsequently described), the display panel 107, a gate driver 8 that drives the gate lines of the display panel 107, and a nonvolatile memory 109 that saves gamma correction data.

**[0004]** The gamma correction circuit 105a includes a gamma correction

data output circuit 111a that converts serial gamma correction data that are input from the outside via an input terminal SD into L-bit (10-bit, for example) parallel gamma correction data which are digital data corresponding to the gamma-corrected set voltages  $VI_1$  to  $VI_m$  and outputs such data; m (nine, for example) registers  $12_1$  to  $12_m$  that input and hold the parallel gamma correction data; 10-bit D/A converters (DAC)  $13_1$  to  $13_m$ , for example, which convert data output by the registers  $12_1$  to  $12_m$  into analog voltages; buffers  $14_1$  to  $14_m$  to which the analog voltages output by the D/A converters (DAC)  $13_1$  to  $13_m$  are input and which output the gamma-corrected set voltages  $VI_1$  to  $VI_m$  by raising the current capacity. The gamma correction data output circuit 111a saves gamma correction data in the nonvolatile memory 109 and fetches the data from the nonvolatile memory 109 when required.

**[0005]** The source driver 6 includes a resistance ladder 15 that generates interpolation voltages by interpolating uniformly with  $m'$  resistances between adjacent voltages of the gamma-corrected set voltages  $VI_1$  to  $VI_m$  (between  $VI_1$  and  $VI_2$ , for example) which are the outputs of the gamma correction circuit 105a; a decoder 16 that outputs the corrected image voltage  $V_o$  by selecting a gamma-corrected set voltage of  $VI_1$  to  $VI_m$  or an interpolation voltage in accordance with the n-bit image data  $D_i$ . The display panel 107 to which the corrected image voltage  $V_o$  is input has  $2^n$  grayscales. That is, supposing n is 8, the display panel 107 has 256 grayscales. The value of  $m'$  is found by  $2^n/(m-1)$ . That is, supposing that n is 8 and m is 9,  $m'$

is 32. For example, if the value of the image data  $D_i$  is 0, the corrected image voltage  $V_o$  is a voltage equal to  $V_{I_1}$  and, if the value of the image data  $D_i$  is 16, the corrected image voltage  $V_o$  is the center voltage of  $V_{I_1}$  and  $V_{I_2}$ .

**[0006]** During an adjustment, the display of the display panel 107 is confirmed in real time and, by inputting serial gamma correction data to the gamma correction circuit 105a via the input terminal SD from the outside, the gamma-corrected set voltages  $V_{I_1}$  to  $V_{I_m}$  are adjusted to the appropriate values. Once the adjustment is complete, the adjusted gamma correction data are saved in the nonvolatile memory 109 and gamma correction data saved in the nonvolatile memory 109 are subsequently used.

**[0007]** The liquid crystal display device which has the same constituent elements as another embodiment of Patent Document 4 is shown in Fig. 7. A liquid crystal display device 102 has a source driver 6, a display panel 107, a gate driver 8 and a nonvolatile memory 109, each of which has substantially the same circuit constitution or the same structure as in the liquid crystal display device 101. The liquid crystal display device 102 also has a gamma correction circuit 105b that has a different constitution in place of the gamma correction circuit 105a. The gamma correction circuit 105b includes a gamma correction data output circuit 111b, two sets of  $m$  registers  $12_{1a}$  to  $12_{ma}$  and  $12_{1b}$  to  $12_{mb}$  that hold data corresponding with the odd number turn/even number turn among horizontal lines (scan lines in a horizontal

direction) of the display panel 107, selectors  $117_1$  to  $117_m$  that switch and select the sets and output data to D/A converters  $13_1$  to  $13_m$  (subsequently described), a selector control circuit 118 to which a horizontal synchronization signal HS which is a synchronization signal for the horizontal lines of the display panel 107 is input and which performs switching control of selectors  $117_1$  to  $117_m$  in accordance with the odd number turn/even number turn among the horizontal lines, D/A converters  $13_1$  to  $13_m$ , and buffers  $14_1$  to  $14_m$ . In addition to the functions of the gamma correction circuit 105a, the gamma correction circuit 105b is able to rapidly change the gamma-corrected set voltages  $VI_1$  to  $VI_m$  in accordance with the odd number turn/even number turn among the horizontal lines and is therefore suited to the driving method of a line inversion system that inverts a positive or negative polarity between the adjacent upper and lower horizontal lines in the display panel 107, for example.

**[0008]** A liquid crystal display device that has the same constituent elements as the other embodiment of Patent Document 4 is shown in Fig. 8. A liquid crystal display device 103 has the source driver 6, display panel 107, gate driver 8, and nonvolatile memory 109, each of which has substantially the same circuit constitution or the same structure as in the liquid crystal display devices 101 or 102. The liquid crystal display device 103 also has a gamma correction circuit 105c with a different constitution in place of the gamma correction circuits 105a or 105b. The gamma correction circuit 105c includes a gamma correction

data output circuit 111b, two sets of m registers 12<sub>1a</sub> to 12<sub>ma</sub> and 12<sub>1b</sub> to 12<sub>mb</sub> which save data corresponding with the odd number turn/even number turn among the horizontal lines, two sets of m D/A converters 13<sub>1a</sub> to 13<sub>ma</sub> and 13<sub>1b</sub> to 13<sub>mb</sub> which are directly connected to the two sets of m registers 12<sub>1a</sub> to 12<sub>ma</sub> and 12<sub>1b</sub> to 12<sub>mb</sub>, selectors 117<sub>1</sub> to 117<sub>m</sub> which switch and select the sets and output analog voltages to the buffers 14<sub>1</sub> to 14<sub>m</sub> (subsequently described), a selector control circuit 118 that performs switching control of the selectors 117<sub>1</sub> to 117<sub>m</sub> by means in accordance with the horizontal synchronization signal HS, and buffers 14<sub>1</sub> to 14<sub>m</sub>. Similarly to the gamma correction circuit 105b, the gamma correction circuit 105c is suited to the driving method of a line inversion system that inverts a positive and negative polarity between the adjacent upper and lower horizontal lines in the display panel 107, for example. However, because the gamma-corrected set voltages VI<sub>1</sub> to VI<sub>m</sub> can be rapidly changed in accordance with the odd number turn/even number turn among the horizontal lines, the gamma correction circuit 105c is more suitable for systems where the frequencies of the horizontal lines of the display panel 107 are high.

**[0009]** Patent Document 1: Japanese Patent Application Laid Open No. H10-108040

Patent Document 2: Japanese Patent Application Laid Open No. H11-32237

Patent Document 3: U.S. Patent No. 5796384

Patent Document 4: Japanese Application No. 2002-326266

## DISCLOSURE OF THE INVENTION

### PROBLEM TO BE SOLVED BY THE INVENTION

**[0010]** Thus, an appropriate gamma correction is performed in the liquid crystal display devices 101, 102, or 103 by adjusting the gamma-corrected set voltages  $VI_1$  to  $VI_m$  to match the each display panel 107.

**[0011]** In recent years, a color liquid crystal display device has become widespread and a further increase in screen size and higher quality display is required. As shown in Fig. 9(a), the display panel of the color liquid crystal display device has a plurality of display elements arranged in two dimensions for the colors of RGB and arranged in the form of stripes in the order, R(red), G(green) and B(blue), in the column direction. Fig. 9(b) is a circuit diagram that corresponds to the arrangement diagram of Fig. 9(a). The display elements of one row are connected to one gate line  $G_i$  (or  $G_{i+1}$  or the like) and provided in the order, R, G, and then B. The display elements of one column are connected to one source line  $S_j$  (or  $S_{j+1}$  or the like) for one color of RGB.

**[0012]** For a preferred image display, the brightness balance for the colors of RGB (that is, the color balance) must be taken in order for there to be no shift to a specified color. However, when there is a breakdown in the color balance as a result of a shift in the



characteristics of the backlight or color filter when the display panel is fabricated, a phenomenon whereby the whole image is afforded a blue shine, for example, by shifting slightly to a specified color arises. The present inventor also considered advances in increasing the screen size of displays and, in order to attempt to further increase the quality of the image, the present inventor focused on studying means for making it relatively simple to adjust the white balance of the display panel that minimizes the above phenomenon and on improving the gamma correction circuit and display panel.

**[0013]** The present invention was conceived for the above reasons and an object thereof is to provide a gamma correction circuit and a display panel that allow the color balance of the display panel to be adjusted as well as a display device that has them.

#### MEANS FOR SOLVING THE PROBLEM

**[0014]** The gamma correction circuit according to a preferred embodiment of the present invention is a gamma correction circuit which outputs a gamma-corrected set voltage in order to correct an image voltage in accordance with a nonlinear correlation between an applied voltage and a brightness of a display element, comprising: a gamma correction data output circuit which outputs a plurality of gamma correction data for each color of RGB; a plurality of registers which input and hold the plurality of gamma correction data; and a plurality of D/A converters each of which converts the data of each of the plurality

of registers into an analog voltage and outputs a gamma-corrected set voltage.

**[0015]** The gamma correction data output circuit of the gamma correction circuit preferably outputs a plurality of gamma correction data that are input from outside for each color of RGB during an adjustment of the gamma-corrected set voltage, and fetches a plurality of gamma correction data for each color of RGB from a nonvolatile memory after the adjustment of the gamma-corrected set voltage, and outputs the plurality of gamma correction data.

**[0016]** The gamma correction data output circuit of the gamma correction circuit preferably outputs a plurality of gamma correction data for each color of RGB in turn in accordance with a horizontal synchronization signal of the display panel. The plurality of registers of the gamma correction circuit are preferably provided for each color of RGB, and the data of the plurality of registers of each color are selected in turn in accordance with a horizontal synchronization signal of a display panel and input to the D/A converters. Alternatively, the plurality of registers and plurality of D/A converters of the gamma correction circuit are preferably provided for each color of RGB and gamma-corrected set voltages of each color are selected in turn in accordance with a horizontal synchronization signal of the display panel and output.

**[0017]** The display panel according to another preferred embodiment of the present invention is a display panel in which a plurality of

display elements are arranged in two dimensions for the colors of RGB and voltages of source lines are applied to a plurality of display elements connected to a selected gate line, wherein a plurality of display elements for one color are connected to each gate lines, and each gate line to which pluralities of display elements for each color are connected is selected in turn in accordance with a horizontal synchronization signal.

**[0018]** The display device according to yet another preferred embodiment of the present invention is a display device, comprising: the gamma correction circuit according to the preferred embodiment of the present invention above; a source driver to which image data are input and which outputs corrected image voltages by selecting the corresponding gamma-corrected set voltages or interpolation voltages thereof; and the display panel according another preferred embodiment of the present invention above in which the gate lines are driven by a gate driver and the corrected image voltages of the source driver are input to the source lines.

#### EFFECTS OF THE INVENTION

**[0019]** According to a preferred embodiment of the present invention, the gamma correction circuit includes a gamma correction data output circuit that outputs a plurality of gamma correction data for each color of RGB is therefore able to perform gamma correction for each color of RGB as a result of being used in conjunction with a display

panel in which a plurality of display elements for one color are connected to one gate line. As a result, the color balance of the display panel can be adjusted. Further, the display panel has a plurality of display elements for one color connected to each gate lines so that a gate line to which a plurality of display elements of each color are connected is selected in turn in accordance with a horizontal synchronization signal. Hence, the color balance can be adjusted by gamma-correcting each color of RGB by means of the gamma correction circuit. A display device having the gamma correction circuit and the display panel is capable of a favorable image display in which there is no shift toward a specified color.

#### BRIEF DESCRIPTION OF THE DRAWINGS

**[0020]** [Fig. 1] Fig. 1 is a circuit diagram of the display device according to a preferred embodiment of the present invention.

[Fig. 2] Fig. 2 shows the display panel of the display device, wherein Fig. 2(a) is an arrangement diagram for the RGB display elements and Fig. 2(b) is the corresponding circuit diagram.

[Fig. 3] Fig. 3 is a circuit diagram of a display device according to another preferred embodiment of the present invention.

[Fig. 4] Fig. 4 is a circuit diagram of a display device according to yet another preferred embodiment of the present invention.

[Fig. 5] Fig. 5 shows a general gamma characteristic.

[Fig. 6] Fig. 6 is a circuit diagram of a display device of

the prior art.

[Fig. 7] Fig. 7 is a circuit diagram of another display device of the prior art.

[Fig. 8] Fig. 8 is a circuit diagram of yet another display device of the prior art.

[Fig. 9] Fig. 9 shows a color display panel of the prior art, wherein Fig. 9(a) is an arrangement diagram of RGB display elements and Fig. 9(b) is the corresponding circuit diagram.

#### EXPLANATION OF REFERENCE NUMERALS

**[0021]** 1, 2, 3 liquid crystal display device (display device)

5a, 5b, 5c gamma correction circuits

6 source driver

7 display panel

8 gate driver

9 nonvolatile memory

11a, 11b gamma correction data output circuits

12<sub>1</sub> to 12<sub>m</sub> registers in gamma correction circuit 5a

12<sub>1</sub>R to 12<sub>m</sub>R R-color registers in gamma correction circuits 5b and 5c

12<sub>1</sub>G to 12<sub>m</sub>G G-color registers in gamma correction circuits 5b and 5c

12<sub>1</sub>B to 12<sub>m</sub>B B-color registers in gamma correction circuits 5b and 5c

13<sub>1</sub> to 13<sub>m</sub> D/A converters in gamma correction circuits 5a and  
5b

13<sub>1R</sub> to 13<sub>mR</sub> R-color D/A converters in gamma correction circuit  
5c

13<sub>1G</sub> to 13<sub>mG</sub> G-color D/A converters in gamma correction circuit  
5c

13<sub>1B</sub> to 13<sub>mB</sub> B-color D/A converters in gamma correction circuit  
5c

#### BEST MODE FOR CARRYING OUT THE INVENTION

**[0022]** The preferred embodiments of the present invention will be described hereinbelow with reference to the drawings. Fig. 1 is a circuit diagram of a liquid crystal display device 1 according to a preferred embodiment of the present invention. The liquid crystal display device 1 has a gamma correction circuit 5a which outputs gamma-corrected set voltages VI<sub>1</sub> to VI<sub>m</sub> for correcting an image voltage in accordance with the nonlinear correlation between an applied voltage and a brightness of a liquid crystal display element, a source driver 6 to which image data Di of n bits (eight bits, for example) are input and which outputs a corrected image voltage Vo to each source line in the display panel 7 (subsequently described) as the applied voltage by selecting a corresponding gamma-corrected set voltage of VI<sub>1</sub> to VI<sub>m</sub> or an corresponding interpolation voltage thereof; a display panel 7 including color liquid crystal display elements, a gate driver 8

that drives the gate lines of the display panel 7, and a nonvolatile memory 9 that saves gamma correction data. Here, the source driver 6 and gate driver 8 have substantially the same circuit constitution as that of the liquid crystal display device 101 mentioned earlier.

**[0023]** The gamma correction circuit 5a includes a gamma correction data output circuit 11a that converts serial gamma correction data that are input sequentially for each color of RGB from the outside via an input terminal SD into L-bit (10-bit, for example) parallel gamma correction data which are digital data corresponding to a gamma-corrected set voltage of  $VI_1$  to  $VI_m$  and outputs such data; m (nine, for example) registers  $12_1$  to  $12_m$  that input and hold the parallel gamma correction data; 10-bit D/A converters (DAC)  $13_1$  to  $13_m$ , for example, each of which converts data output by each of the registers  $12_1$  to  $12_m$  into an analog voltage; buffers  $14_1$  to  $14_m$  to which the analog voltages output by the D/A converters (DAC)  $13_1$  to  $13_m$  are input and which output the gamma-corrected set voltages  $VI_1$  to  $VI_m$  by raising the current capacity. The gamma correction data output circuit 11a converts serial gamma correction data that are sequentially input for each color of RGB from the outside via the input terminal SD during the adjustment of the gamma-corrected set voltages  $VI_1$  to  $VI_m$  into parallel gamma correction data, outputs the parallel gamma correction data to the registers  $12_1$  to  $12_m$  and saves the gamma correction data for each color of RGB (that is, R gamma correction data, G gamma correction data, and B gamma correction data) in the nonvolatile memory 9. The gamma

correction data output circuit 11a fetches gamma correction data saved in the nonvolatile memory 9 for each color of RGB in turn in accordance with the horizontal synchronization signal HS of the display panel 7 after adjusting the gamma-corrected set voltages  $VI_1$  to  $VI_m$  and outputs the gamma correction data to the registers  $12_1$  to  $12_m$ .

**[0024]** The display panel 7 has a plurality of display elements arranged in two dimensions for the colors of RGB as shown in Fig. 2(a) and arranged in the form of stripes in the order, R(red), G(green) and B(blue) in the row direction. Fig. 2(b) is a circuit diagram that corresponds with the arrangement diagram of Fig. 2(a). A plurality of display elements for one color of RGB are connected to each one row, that is, each gate line  $Gi$  (or  $Gi_{+1}$  or the like). A plurality of display elements are connected in the order, R, G, and then B to each one column, that is, one source line  $Sj$  (or  $Sj_{+1}$  or the like). In the display panel 7, a gate line  $Gi$  (or  $Gi_{+1}$  or the like) to which a plurality of display elements of each color are connected is selected by the gate driver 8 in turn in accordance with the horizontal synchronization signal HS and a voltage of the source line  $Sj$  (or  $Sj_{+1}$  or the like) is applied to each of the plurality of display elements connected to the selected gate line  $Gi$  (or  $Gi_{+1}$  or the like).

**[0025]** The operation on and after the adjustment of the gamma-corrected set voltages  $VI_1$  to  $VI_m$  will be described next. First, a description for the operation on the adjustment of the gamma-corrected set voltages  $VI_1$  to  $VI_m$  will be provided. For example, when a plurality



of R gamma correction data are input to the gamma correction circuit 5a in sync with the horizontal synchronization signal HS, R gamma-corrected set voltages  $VI_1$  to  $VI_m$  that correspond with the gamma correction data are output. An image voltage  $V_o$  for the color R corrected by means of the gamma-corrected set voltages  $VI_1$  to  $VI_m$  is output from the source driver 6 to the display panel 7 as an applied voltage. Here, the important thing is that a gate line to which the R display elements in the display panel 7 are connected be selected. That is, R image voltages that have been corrected by means of the R gamma-corrected set voltages  $VI_1$  to  $VI_m$  that correspond with the R gamma correction data input to the gamma correction circuit 5a are applied to the R display elements. A plurality of G gamma correction data are then input to the gamma correction circuit 5a in sync with the next horizontal synchronization signal HS. G image voltages that have been corrected by the corresponding G gamma-corrected set voltages  $VI_1$  to  $VI_m$  are applied to the G display elements. The same operation is carried out for the color B and this operation is repeated for the colors of RGB. As detailed hereinabove, a gamma correction is performed for each color of RGB and gamma correction data values from the outside are changed while checking the display of the display panel 7 in real time and the gamma-corrected set voltages  $VI_1$  to  $VI_m$  are adjusted to appropriate voltages.

**[0026]** Once the adjustment is completed, the adjusted gamma correction data are saved in the nonvolatile memory 9 and, subsequently,

the gamma correction data saved in the nonvolatile memory 9 are used. Here, the gamma correction data saved in the nonvolatile memory 9 correspond with the gamma characteristics of each color of RGB. The act of saving the gamma correction data in the nonvolatile memory 9 may be performed each time new gamma correction data are input from the outside rather than only when the adjustment is complete.

**[0027]** The gamma correction data saved in the nonvolatile memory 9 are used after the gamma-corrected set voltages  $VI_1$  to  $VI_m$  have been adjusted for each color of RGB. However, in this case, the fetching of the gamma correction data saved in the nonvolatile memory 9 is performed for each color of RGB in turn in accordance with the horizontal synchronization signal HS. Thereafter, when R gamma correction data are fetched upon receipt of the horizontal synchronization signal HS, for example, the data are output to the registers  $12_1$  to  $12_m$ , converted into analog voltages by means of the D/A converters  $13_1$  to  $13_m$ , and output as R gamma-corrected set voltages  $VI_1$  to  $VI_m$  via the buffers  $14_1$  to  $14_m$ . R image voltage  $V_o$  that have been corrected by means of the gamma-corrected set voltages  $VI_1$  to  $VI_m$  are output from the source driver 6 to the display panel 7 as the applied voltages, whereupon, as is the case during the abovementioned adjustment, One gate line to which the R display elements are connected in the display panel 7 are selected. The same operation is also performed for G and B and these operations are repeated for the colors of RGB. That is, the gamma correction circuit 5a outputs gamma-corrected set voltages  $VI_1$

to  $VI_m$  for each color of RGB in turn in accordance with the horizontal synchronization signal HS and one gate line of the display panel 7 to which the display elements for the associated color are connected is selected. As mentioned earlier, gamma correction is suitably performed for each color of RGB.

**[0028]** Thus, the gamma correction circuit 5a is able to perform gamma correction on each color of RGB and, accordingly, adjust the white balance of the display panel. The display panel 7 has a plurality of display elements connected to gate lines so that one gate line to which a plurality of display elements for one color are connected is selected in turn in accordance with the horizontal synchronization signal HS. Therefore, by performing gamma correction on each color of RGB by means of the gamma correction circuit 5a, the white balance can be adjusted. The liquid crystal display device 1 that has the gamma correction circuit 5a and the display panel 7 is capable of a favorable image display without a shift to a specified color.

**[0029]** A liquid crystal display device 2 of another preferred embodiment of the present invention will be described next on the basis of Fig. 3. The liquid crystal display device 2 represents an improvement of the liquid crystal display device 1 from the perspective of minimizing the current consumption. The liquid crystal display device 2 has a source driver 6, a display panel 7, a gate driver 8, and a nonvolatile memory 9, each of which has substantially the same circuit constitution or the same structure as that of the liquid crystal

display device 1. The liquid crystal display device 2 also has a gamma correction circuit 5b which has a different constitution in place of the gamma correction circuit 5a. The gamma correction circuit 5b includes a gamma correction data output circuit 11b, three sets of m registers  $12_1R$  to  $12_mR$ ,  $12_1G$  to  $12_mG$ , and  $12_1B$  to  $12_mB$  which are provided for each color of RGB, selectors  $17_1$  to  $17_m$  which switch and select any of these sets and output data to the D/A converters  $13_1$  to  $13_m$  (subsequently described), a selector control circuit 18 that performs switching control of the selectors  $17_1$  to  $17_m$  in turn in accordance with the horizontal synchronization signal HS, D/A converters  $13_1$  to  $13_m$  and buffers  $14_1$  to  $14_m$ .

**[0030]** The gamma correction circuit 5b fetches all the gamma correction data for the colors of RGB from the nonvolatile memory 9 when the power is turned ON and causes the three sets of registers  $12_1R$  to  $12_mR$ ,  $12_1G$  to  $12_mG$  and  $12_1B$  to  $12_mB$  to hold the gamma correction data. The data held for each color of RGB are selected in turn in accordance with the horizontal synchronization signal HS and input to the D/A converters  $13_1$  to  $13_m$ , converted into analog voltages, and then output as gamma-corrected set voltages  $VI_1$  to  $VI_m$  via the buffers  $14_1$  to  $14_m$ . Thus, although the liquid crystal display device 1 fetches gamma correction data saved in the nonvolatile memory 9, that is, accesses the nonvolatile memory 9 for each horizontal synchronization signal HS, the liquid crystal display device 2 is able to minimize current consumption because the access is made to the nonvolatile memory

9 only when the power is turned on and the number of times access is made is markedly reduced.

**[0031]** A liquid crystal display device 3, which is yet another preferred embodiment of the present invention, will be described next with reference to Fig. 4. The liquid crystal display device 3 has a source driver 6, a display panel 7, a gate driver 8, and a nonvolatile memory 9, each of which has substantially the same circuit constitution or the same structure as that of the liquid crystal display devices 1 or 2. The liquid crystal display device 3 also has a gamma correction circuit 5c which has a different constitution in place of the gamma correction circuits 5a or 5b. The gamma correction circuit 5c includes a gamma correction data output circuit 11b, three sets of m registers 12<sub>1R</sub> to 12<sub>mR</sub>, 12<sub>1G</sub> to 12<sub>mG</sub>, and 12<sub>1B</sub> to 12<sub>mB</sub> which are provided for the colors of RGB, three sets of m D/A converters 13<sub>1R</sub> to 13<sub>mR</sub>, 13<sub>1G</sub> to 13<sub>mG</sub>, and 13<sub>1B</sub> to 13<sub>mB</sub> which are directly connected to the three sets of m registers 12<sub>1R</sub> to 12<sub>mR</sub>, 12<sub>1G</sub> to 12<sub>mG</sub>, and 12<sub>1B</sub> to 12<sub>mB</sub>, selectors 17<sub>1</sub> to 17<sub>m</sub> which switch and select any of these sets and output analog voltages to the buffers 14<sub>1</sub> to 14<sub>m</sub> (subsequently described), a selector control circuit 18 that performs switching control of the selectors 17<sub>1</sub> to 17<sub>m</sub> in turn in accordance with the horizontal synchronization signal HS, and buffers 14<sub>1</sub> to 14<sub>m</sub>.

**[0032]** The gamma correction circuit 5c fetches all the gamma correction data for the colors of RGB from the nonvolatile memory 9 when the power is turned ON, and then causes the three sets of registers

12<sub>1</sub>R to 12<sub>m</sub>R, 12<sub>1</sub>G to 12<sub>m</sub>G and 12<sub>1</sub>B to 12<sub>m</sub>B to hold the gamma correction data and causes the D/A converters 13<sub>1</sub>R to 13<sub>m</sub>R, 13<sub>1</sub>G to 13<sub>m</sub>G, 13<sub>1</sub>B to 13<sub>m</sub>B to convert the gamma correction data into analog voltages for the colors of RGB. y. The analog voltages for each color of RGB are selected in turn in accordance with the horizontal synchronization signal HS, input to the buffers 14<sub>1</sub> to 14<sub>m</sub> and then output as gamma-corrected set voltages VI<sub>1</sub> to VI<sub>m</sub>. Therefore, the gamma correction circuit 5c is able to minimize the current consumption of the liquid crystal display device 3 and, because the data for the colors of RGB have already been converted into analog voltages, rapidly switch the gamma-corrected set voltages VI<sub>1</sub> to VI<sub>m</sub>. Hence, the gamma correction circuit 5c is suitable for a display device that requires high-speed processing in which the frequency of the horizontal lines of the display panel 7 is high.

**[0033]** If the current output capacity of the D/A converter (DAC) is sufficient, buffers 14<sub>1</sub> to 14<sub>m</sub> can also be omitted from the gamma correction circuits 5a, 5b, or 5c above.

**[0034]** Moreover, the present invention is not limited to the above embodiments. A variety of design modifications within the scope of the items appearing in the claims are possible. For example, although a liquid crystal display device is described in this embodiment, the gamma correction circuit, display panel, and display device of the present invention are not limited to a liquid crystal display device and can be applied to display devices (an organic EL display device,

for example) requiring gamma correction.